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# Peak ventilatory responses during cycling and swimming in pregnant and nonpregnant women

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**Spinnewijn, Wilhelmina E. M., Henk C. S. Wallenburg, Piet C. Struijk, and Frederik K. Lotgering.** Peak ventilatory responses during cycling and swimming in pregnant and nonpregnant women. *J. Appl. Physiol.* 81(2): 738–742, 1996.—This study was designed to determine whether pregnancy affects peak  $\text{O}_2$  uptake ( $\dot{V}\text{O}_{2\text{peak}}$ ) during swimming compared with cycling. We studied 11 women at 30–34 wk gestation and 8–12 wk postpartum. We measured heart rate (HR),  $\text{O}_2$  uptake ( $\dot{V}\text{O}_2$ ),  $\text{CO}_2$  output ( $\dot{V}\text{CO}_2$ ), minute ventilation ( $\dot{V}\text{E}$ ), and lactic acid concentration. Peak HR was not significantly affected by the type of exercise or by pregnancy.  $\dot{V}\text{O}_{2\text{peak}}$  was 9% lower during swimming than during cycling but was not affected by pregnancy, with values for pregnancy cycling, pregnancy swimming, postpartum cycling, and postpartum swimming of  $2.36 \pm 0.12$ ,  $2.11 \pm 0.11$ ,  $2.29 \pm 0.10$ , and  $2.12 \pm 0.07$  l/min, respectively. Peak  $\dot{V}\text{CO}_2$  ( $\dot{V}\text{CO}_{2\text{peak}}$ ) and peak  $\dot{V}\text{E}$  were significantly lower during swimming than during cycling by 18–25%, but only  $\dot{V}\text{CO}_{2\text{peak}}$  during swimming was affected by pregnancy (–10%). Lactic acid concentrations were 12–17% lower after swimming than after cycling and 17–31% lower during pregnancy than postpartum. We conclude that perceived maximal exertion is reached at a lower percent maximal  $\dot{V}\text{O}_2$  in swimming than in cycling and that the reduced energy expenditure is reflected by lower  $\dot{V}\text{O}_{2\text{peak}}$ ,  $\dot{V}\text{CO}_{2\text{peak}}$ , and peak  $\dot{V}\text{E}$ . Pregnancy, however, does not affect  $\dot{V}\text{O}_{2\text{peak}}$  in cycling or swimming.

gestation; peak oxygen uptake; ventilation; exercise; lactic acid

SWIMMING IS OFTEN RECOMMENDED to maintain a good physical condition during gestation. Yet relatively little is known about the physiological effects of swimming in pregnancy. In untrained nonpregnant individuals the highest  $\text{O}_2$  uptake ( $\dot{V}\text{O}_{2\text{peak}}$ ) that can be attained during swimming is ~87% of that reached by cycling (2). When  $\dot{V}\text{O}_{2\text{peak}}$  during cycling is known to be unaffected by pregnancy (15, 21, 25), one would expect that this would be true also for other types of non-weight-bearing exercise, which includes swimming. However, in the only published study on  $\dot{V}\text{O}_{2\text{peak}}$  that compares swimming in pregnant and postpartum women (21), swim  $\dot{V}\text{O}_{2\text{peak}}$  was 17% lower during gestation than postpartum. The investigators did not offer a compelling theoretical rationale for the lower swim  $\dot{V}\text{O}_{2\text{peak}}$  during pregnancy but suggested that the water environment could be responsible or that pregnant women do not push themselves as hard during swimming as during cycling.

The purpose of our study was to test the hypothesis that, contrary to the unexpected finding in the literature (21), swim  $\dot{V}\text{O}_{2\text{peak}}$  is not reduced by pregnancy and is lower than cycle  $\dot{V}\text{O}_{2\text{peak}}$  in pregnant as well as

in nonpregnant women. We used a progressive continuous exercise protocol for longitudinal comparison of the ventilatory responses to swimming and cycling in pregnant and postpartum women.

## METHODS

**Subjects.** From January 1994 to December 1994 we studied 11 healthy women at 30–35 wk pregnancy and 8–12 wk postpartum. All women had uncomplicated singleton pregnancies. The physical fitness of the subjects who entered the study was variable and ranged from women with a sedentary life-style to those who participated in recreational sports. All volunteers were familiar with cycling and breaststroke swimming without participating in a physical conditioning program or specific training in either sport before or during the study period. The study was approved by the Hospital and University Ethics Committee, and all women recruited gave their informed consent.

**Exercise protocol.** Each subject underwent a total of six rapidly progressive maximal tests: three cycle and three swim tests. The first set of tests, cycling and swimming, was performed to allow the subjects to become acquainted with the experimental circumstances; the results of these tests were discarded. The second set of tests was performed at 30–34 wk of pregnancy and the third set of tests at 8–12 wk postpartum. The cycle and swim tests of each period took place on separate days of the same week at approximately the same time of day for each subject. The order of the cycle and swim tests was assigned randomly.

Before each test we measured body mass, performed a routine physical and obstetric examination, and monitored the fetal heart rate (HR; HP 8040A fetal HR monitor, Hewlett-Packard, Boeblingen, Germany), with the volunteer in semi-recumbent position, to confirm the health of all individuals participating in the study.

The cycle tests took place in an air-conditioned room kept at 21°C on an electrically braked cycle ergometer (Ergoline 900, Mijnhardt, Bunnik, The Netherlands). We used a Sport tester (Polar electro, Kempele, Finland), with the electrodes placed on both sides of the thorax just below the breasts and the receiver around the wrist to measure the HR continuously and to store the HR data as 30-s average values. After 20 min of rest the subject was seated on the cycle ergometer and connected by a rubber mouthpiece, attached to a two-way valve (model 2700 series, Hans Rudolph, Kansas City, MO) with a flexible 0.6-m inflow and 2.5-m outflow tube (30 mm ID), to a gas flowmeter and  $\text{O}_2$  and  $\text{CO}_2$  analyzer (Oxycon-4, Mijnhardt). A noseclip prevented nasal breathing. Baseline measurements were taken during 5 min of sitting at rest; then the volunteer started to cycle. The initial power (20 W) was increased by 20 W/min until the subject reached perceived maximal exertion. Recovery values were taken during 5 min with the volunteer sitting at rest on the cycle ergometer; then she was returned to the semirecumbent position and a venous blood sample was taken, 5–6 min after the



exercise, to determine the plasma lactic acid concentration. Thereafter the fetal HR was recorded for 20 min.

The swim tests took place in a  $8.0 \times 4.5$ -m pool with a water temperature of  $33^\circ\text{C}$  and an air temperature of  $26^\circ\text{C}$ . The pool had a movable platform, which allowed us to adjust the level of immersion of the upright subject. We used a tethered swim ergometer modified after Costill (5). The ergometer consists of an adjustable weight connected by a pulley to a belt around the woman's waist. Because the HR signal was sometimes not picked up by the wrist receiver during swimming, a second receiver was attached to the swimsuit. After 20 min of rest the volunteer stood on the platform of the pool in air without immersion. Baseline measurements were taken during 5 min, as before the cycle test. The platform was then lowered, and further measurements were taken during 5 min of head-out immersion with the subject standing in the water. After 10 min of standing at rest, the subject started to swim with a breaststroke. The initial weight of 0.5 kg, connected to the woman's waist by the pulley, was increased by 0.5 kg every minute until the subject reached perceived maximal exertion and could no longer sustain the pull. She then recovered for 5 min standing in the water, after which the study protocol was identical to that after cycling.

**Measurements.** We continuously measured gas flow and expiratory  $O_2$  and  $CO_2$  concentrations (Oxycon-4, Mijnhardt) and recorded time. All data were stored on a computer (model PCS286, Olivetti, Ivrea, Italy). On-line 30-s average values of  $O_2$  uptake ( $\dot{V}O_2$ ),  $CO_2$  output ( $\dot{V}CO_2$ ), minute ventilation ( $\dot{V}E$ ), and respiratory exchange ratio (R) were calculated; 60-s changes in power and 30-s average maternal HR values were added off-line. The venous plasma lactic acid concentrations were determined from 4.5-ml blood samples, drawn anaerobically into EDTA tubes, and kept on ice until analysis within 1 h after sampling with the use of the oxidation method (ACA-analyzer, Du Pont, Wilmington, DE). We defined peak values of a variable as those values measured at the highest power. We defined  $\dot{V}O_2$  plateau as an increase in  $\dot{V}O_2$  of  $<5\%$  in response to an increase in power.

**Statistical analysis.** From the 30-s average values we calculated mean values at 2.0–4.5 min of rest (statistical package; SPSS pc V5.02, Chicago, IL). For each test period and each variable under consideration, we computed means  $\pm$  SE. We used two-way analysis of variance (Friedman) and Wilcoxon's signed-ranks test to assess differences between paired variables.  $P < 0.05$  was taken as the level of significance.

## RESULTS

Of the 13 women recruited, two found the test too physically demanding, indicated that they did not perform at their maximum, and had maximal HR  $<140$  beats/min. The data of these two women were discarded; the remaining 11 women completed all tests. Gestational age at the time of the test was  $33.1 \pm 0.5$  wk; the postpartum test was performed  $12.0 \pm 0.4$  wk after delivery. The fetal HR patterns during recovery from cycling and swimming were similar to those in the control period, without significant changes in basal fetal HR, loss of variability, or appearance of decelerations that might indicate fetal distress.

All 11 women, 7 primiparae and 4 multiparae, remained healthy throughout the study period and delivered healthy infants. Age at delivery was  $32.5 \pm 1.3$  yr, gestational age was  $40.1 \pm 0.3$  wk, and birth weight

was  $3.45 \pm 0.12$  kg. Eight women were lactating at the time of the postpartum test. Body mass during pregnancy ( $74.9 \pm 3.0$  kg) was significantly different from postpartum values ( $67.6 \pm 2.9$  kg).  $\dot{V}O_{2\text{peak}}$  per kilogram of body mass determined during postpartum cycling was taken as an index of physical fitness and varied between 28 and 57  $\text{ml } O_2 \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ , with a mean of  $34 \text{ ml } O_2 \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ . There was no significant relationship between the level of physical fitness, parity, or lactation status and the difference between  $\dot{V}O_{2\text{peak}}$  values in pregnancy and postpartum for either type of exercise. Therefore, we report on the 11 volunteers as a uniform group.

**Control values at rest.** The effects of pregnancy on control values are summarized in Table 1.

In all positions studied, HR,  $\dot{V}O_2$ ,  $\dot{V}CO_2$ , and  $\dot{V}E$  at rest were higher in pregnancy than postpartum. The increase in  $\dot{V}E$  in pregnancy was caused by a significant rise in tidal volume ( $V_T$ ), without a difference in breathing rate. With the subjects seated on the cycle ergometer, the pregnancy-induced increase was 11% in HR, 10% for  $\dot{V}O_2$ , 13% for  $\dot{V}CO_2$ , and 15% for  $\dot{V}E$ , whereas R was not affected, with values of  $0.81 \pm 0.02$  (pregnancy and postpartum).

Compared with sitting, standing in air was associated with somewhat higher values of HR,  $\dot{V}O_2$ ,  $\dot{V}CO_2$ , and  $\dot{V}E$  in the pregnant and nonpregnant state, but the differences reached statistical significance only for HR (10%),  $\dot{V}O_2$  (12%), and  $\dot{V}E$  (13%) in the pregnant state. R values in standing position,  $0.80 \pm 0.01$  and  $0.81 \pm 0.02$  in pregnancy and postpartum, respectively, were not different from those in the sitting position.

Compared with standing in air, standing in water was associated with a significantly (17%) lower HR in the pregnant and the nonpregnant state.  $\dot{V}O_2$ ,  $\dot{V}CO_2$ , and  $\dot{V}E$  were higher in the water than in air, but the increases were statistically significant only for  $\dot{V}CO_2$  and for  $\dot{V}E$  in the nonpregnant state. R values in the water,  $0.86 \pm 0.02$  and  $0.91 \pm 0.04$  in pregnancy and

Table 1. Effect of pregnancy on control values at rest

	HR, beats/min	$\dot{V}O_2$ , l/min	$\dot{V}CO_2$ , l/min	$\dot{V}E$ , l/min
Sitting				
Pregnant	$90 \pm 3^*$	$0.33 \pm 0.01$	$0.27 \pm 0.01$	$11.95 \pm 0.42^*$
Postpartum	$81 \pm 3$	$0.30 \pm 0.02$	$0.24 \pm 0.01$	$10.36 \pm 0.34$
Standing, in air				
Pregnant	$99 \pm 3^{*\dagger}$	$0.37 \pm 0.02^{*\dagger}$	$0.30 \pm 0.02^*$	$13.54 \pm 0.68^{*\dagger}$
Postpartum	$83 \pm 3$	$0.32 \pm 0.01$	$0.25 \pm 0.01$	$10.69 \pm 0.46$
Standing, in water				
Pregnant	$82 \pm 3^{*\dagger\ddagger}$	$0.38 \pm 0.02^{*\dagger}$	$0.33 \pm 0.01^\dagger$	$14.06 \pm 0.63^{*\dagger}$
Postpartum	$69 \pm 2^{\dagger\ddagger}$	$0.35 \pm 0.02^\dagger$	$0.31 \pm 0.01^{\dagger\ddagger}$	$11.99 \pm 0.54^{\dagger\ddagger}$

Values are means  $\pm$  SE;  $n = 11$ . HR, heart rate;  $\dot{V}O_2$ ,  $O_2$  uptake;  $\dot{V}CO_2$ ,  $CO_2$  output.  $^*P < 0.05$  compared with postpartum control;  $^\dagger P < 0.05$  compared with sitting;  $^\ddagger P < 0.05$  compared with standing in air.



Table 2. Effect of pregnancy on peak responses during cycling and swimming

	Exercise Time, min	HR, beats/min	$\dot{V}O_2$ , l/min	$\dot{V}CO_2$ , l/min	$\dot{V}E$ , l/min
Cycling					
Pregnant	10.05 $\pm$ 0.61	171 $\pm$ 7	2.36 $\pm$ 0.12	2.76 $\pm$ 0.16	92.55 $\pm$ 5.34
Postpartum	9.77 $\pm$ 0.46	180 $\pm$ 6	2.29 $\pm$ 0.10	2.82 $\pm$ 0.11	86.37 $\pm$ 3.60
Swimming					
Pregnant	9.77 $\pm$ 0.45	169 $\pm$ 6	2.11 $\pm$ 0.11†	2.08 $\pm$ 0.09*†	73.36 $\pm$ 4.38†
Postpartum	10.18 $\pm$ 0.59	171 $\pm$ 5	2.12 $\pm$ 0.07†	2.32 $\pm$ 0.09†	70.35 $\pm$ 3.32†

Values are means  $\pm$  SE;  $n = 7$  for HR,  $n = 11$  for all other variables. \* $P < 0.05$  compared with postpartum control; † $P < 0.05$  compared with cycling.

postpartum, respectively, were significantly higher than in air (+8%) in pregnancy as well as postpartum (+12%).

Compared with sitting in air, standing in water was associated with significantly lower values of HR and higher values of  $\dot{V}O_2$ ,  $\dot{V}CO_2$ ,  $\dot{V}E$ , and  $R$  in pregnant and postpartum women.

**Peak aerobic exercise.** The imposed load was increased linearly with time for cycling and swimming, and the mean time to reach perceived maximal exertion (10 min) was not significantly different between periods or test types (Table 2).

**Cycling.** HR and  $\dot{V}O_2$  showed a linear increase with power. Absolute peak values of HR ( $HR_{peak}$ ),  $\dot{V}O_2$  ( $\dot{V}O_{2peak}$ ),  $\dot{V}CO_2$  ( $\dot{V}CO_{2peak}$ ), and  $\dot{V}E$  ( $\dot{V}E_{peak}$ ) during cycling were not significantly different between pregnant and postpartum women. A  $\dot{V}O_2$  plateau was found in 73% of the tests. In the absence of significant differences in  $\dot{V}O_{2peak}$  and  $\dot{V}CO_{2peak}$ , also no significant difference in  $R$  was observed between test periods, with values of  $1.18 \pm 0.03$  and  $1.24 \pm 0.02$  in pregnancy and postpartum, respectively.  $\dot{V}E_{peak}$  was increased slightly (7%,  $P = NS$ ) during gestation compared with postpartum as a result of a 10% higher  $V_T$ , with no difference in respiratory rate. The venous lactic acid concentration during recovery was significantly lower in pregnancy ( $8.0 \pm 0.7$  mmol/l) than postpartum ( $9.6 \pm 0.6$  mmol/l).

**Swimming.** Most participants found the low initial weight (0.5 kg) uncomfortable and reacted with an irregular stroke technique to remain floating. After ~3 min (1.5 kg) the strokes became more regular. This was

reflected in HR and  $\dot{V}O_2$ , which were irregular during the first 3 min of swimming but increased linearly with time thereafter. No reliable HR signal was obtained in 5 of 22 swim tests. Therefore only seven data pairs were available for comparison. As with cycling,  $HR_{peak}$ ,  $\dot{V}O_{2peak}$ , and  $\dot{V}E_{peak}$  during swimming were not significantly different between pregnant and postpartum women. A  $\dot{V}O_2$  plateau was found in 73% of the tests.  $\dot{V}O_{2peak}$  was not affected by gestation, but  $\dot{V}CO_{2peak}$  during swimming was significantly lower during pregnancy than postpartum (−10%). As a consequence,  $R$  was on average 11% lower during pregnancy ( $1.01 \pm 0.03$ ) than postpartum ( $1.14 \pm 0.03$ ).  $\dot{V}E_{peak}$  was increased slightly (4%,  $P = NS$ ) during pregnancy compared with postpartum as a result of 8% ( $P = NS$ ) higher  $V_T$ , with no difference in respiratory rate. The venous lactic acid concentration during recovery from swimming was significantly lower in pregnancy ( $5.8 \pm 0.5$  mmol/l) than postpartum ( $8.4 \pm 1.0$  mmol/l).

**Swimming vs. cycling.** Exercise time and  $HR_{peak}$  were not significantly different between exercise types. However,  $\dot{V}O_{2peak}$ ,  $\dot{V}CO_{2peak}$ , and  $\dot{V}E_{peak}$  were significantly lower during swimming than during cycling in pregnancy and in the postpartum period. A typical example of the relationship between  $\dot{V}O_2$  and  $\dot{V}CO_2$  during cycling and swimming in pregnancy and postpartum is shown in Fig. 1.  $\dot{V}O_{2peak}$  values were lower during swimming than during cycling by 11% in pregnancy and by 7% postpartum and  $\dot{V}CO_{2peak}$  values were lower by 25% in pregnancy and 18% postpartum. As a result

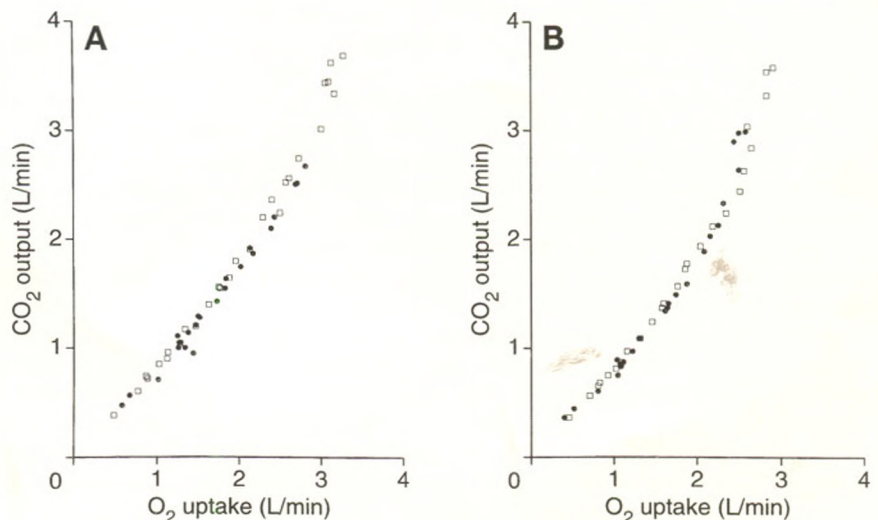


Fig. 1. Relationship between  $O_2$  uptake and  $CO_2$  output during cycling (□) and swimming (●) in pregnancy (A) and postpartum (B). Swim and cycle data are superimposed on each other. In pregnancy and postpartum a lower peak value is obtained in swimming than in cycling.



of the more pronounced reduction in  $\dot{V}CO_{2\text{peak}}$  than in  $\dot{V}O_{2\text{peak}}$  during swimming than during cycling, peak values of  $R$  were significantly lower during swimming, by 14% in pregnancy and by 6% postpartum. Associated with the reduced  $\dot{V}CO_{2\text{peak}}$  during swimming,  $\dot{V}E_{\text{peak}}$  was also markedly lower during swimming than during cycling, by 21% in pregnancy and by 19% postpartum. The lower  $\dot{V}E_{\text{peak}}$  during swimming resulted from a significantly lower  $V_T$  during swimming than during cycling, by 18% in pregnancy and by 16% postpartum, with no difference in peak respiratory rate. The venous lactic acid concentration was significantly lower during recovery from swimming than from cycling by 27% in pregnancy and by a statistically not significant 12% postpartum.

## DISCUSSION

$\dot{V}O_2$  during swimming is dependent on training, swimming technique, and body dimensions (9, 11). The volunteers in our study had a variable level of physical fitness and were familiar with cycling and breaststroke swimming, without being competitive cyclists or swimmers. We chose to study breaststroke swimming, because this technique requires more leg work and less arm work than other types of swimming (10) and, for that reason, allows the best possible comparison with cycling. We used tethered swimming, because the experimental setup is relatively simple and because it allows a controlled stepwise increase in power, analogous to the stepwise increasing cycle protocol. Body dimensions at 35-wk gestation are different from those postpartum, but it remains speculative whether this affects the physiological responses to swimming. It has been suggested that the hydrostatic pressure could reduce  $V_T$  in pregnant women, because the enlarging uterus could be forced toward the diaphragm and limit its contractility (21). This seems unlikely, because immersion has been shown not to affect  $V_T$  or even to tend to increase it (4, 8, 9). We observed no significant change (8%) in peak  $V_T$  during swimming in pregnancy compared with postpartum.

The resting changes observed in our study were in accordance with those reported in the literature. Resting values of HR,  $\dot{V}O_2$ ,  $\dot{V}CO_2$ , and  $\dot{V}E$  were higher during pregnancy than postpartum. This reflects the increased cardiac output, the metabolic needs of the fetus, and the high circulating levels of progesterone (6, 13, 16, 17, 23). Standing values are higher than sitting values because of circulatory changes and the effort to maintain an upright position. These positional changes are more prominent in pregnant than in postpartum women (13, 15, 26). The hydrostatic pressure during immersion increases stroke volume through an increase in venous return to the heart (24), which reduces HR despite an increase in metabolism to compensate for heat loss (20). We chose a water temperature of 33°C to avoid marked heat loss during immersion, which is more prominent in pregnant than in postpartum women (20) and which would have significantly increased metabolic heat production and  $\dot{V}O_2$  at rest (22) before exercise. Given the rapidly progressive protocol, it

seems unlikely that an increased body temperature would have negatively affected swim  $\dot{V}O_{2\text{peak}}$  in our experiments.

Our results with regard to perceived maximal cycling are similar to those previously reported by our group in a comparable group of women (15). During pregnancy there is no difference in  $\dot{V}O_{2\text{peak}}$  compared with postpartum controls but a slight tendency to lower HR<sub>peak</sub>, lower  $\dot{V}CO_{2\text{peak}}$ , and higher  $\dot{V}E_{\text{peak}}$ . To the best of our knowledge, only one study has been reported on maximal swimming responses in pregnant compared with postpartum women (21). The authors found that swim  $\dot{V}O_{2\text{peak}}$  was 17% lower during pregnancy than postpartum and that  $\dot{V}O_{2\text{peak}}$  was lower during the swim than during the cycle trials by 24% in pregnancy and by 7% ( $P = \text{NS}$ ) postpartum. In contrast to their progressive continuous cycle protocol, they used an interval protocol to assess swimming responses. Resistance was increased on the basis of the volunteer's rating of perceived exertion and HR but was otherwise unspecified, and the exercise time to maximal effort was not reported. Thus one cannot exclude the possibility that differences in power may have contributed to their observation of a lower  $\dot{V}O_{2\text{peak}}$  during swimming, but not during cycling, in pregnancy. We studied tethered swimming responses with the use of a progressive continuous protocol designed to achieve optimal comparison with the cycle protocol. Indeed, the average exercise time to perceived maximal exertion was not different between the swim and cycle trials or between the pregnant and postpartum volunteers.

We found 9% lower  $\dot{V}O_{2\text{peak}}$  values during swimming than during cycling. Although this might suggest that the volunteers simply pushed themselves less during swimming than during cycling, this seems unlikely for several reasons. First, a  $\dot{V}O_2$  plateau was reached equally often in the swim and cycle trials (73%). Furthermore, the observed difference was similar to that reported in untrained nonpregnant subjects. It probably reflects the more extensive use in swimming of arm than of leg muscles (2, 10, 19). Untrained swimmers may reach maximal voluntary exertion at a lower maximal  $\dot{V}O_2$  during swimming than during cycling. The smaller overall energy expenditure (7, 18) is illustrated by the fact the  $\dot{V}CO_2$ - $\dot{V}O_2$  plots of swim and cycle test data show identical patterns, except the peak is lower during the swim than during the cycle trial (Fig. 1). As a consequence, the venous lactic acid concentrations were also lower after the swim than after the cycle tests. More important, however, than the fact that swim  $\dot{V}O_{2\text{peak}}$  is lower than cycle  $\dot{V}O_{2\text{peak}}$  is the finding that swim  $\dot{V}O_{2\text{peak}}$  appears to be independent of pregnancy.

Relative to  $\dot{V}O_{2\text{peak}}$ ,  $\dot{V}CO_{2\text{peak}}$  was lower during swimming than during cycling, and consequently peak values of  $R$  were significantly lower during swimming. Because  $\dot{V}CO_2$  is known to increase more steeply than does  $\dot{V}O_2$  above the ventilatory threshold (3, 14), this was to be expected when overall energy expenditure was lower during the swim test than during the cycle test.



$\dot{V}E_{\text{peak}}$  is lower during swimming than during cycling, in absolute terms and relative to  $\dot{V}CO_2$ . The relative hypoventilation during swimming is attributed to more difficult mechanics as a result of hydrostatic pressure on the thorax (1, 12). However, despite the relative hypoventilation, the arterial  $O_2$  pressure and saturation are unaffected in nonpregnant individuals (1, 12). This is probably true also for pregnant women.

**Significance.** We conclude that perceived maximal exertion is reached at a lower percent maximal  $\dot{V}O_2$  in swimming than in cycling and that the reduced energy expenditure is reflected by lower peak values of  $\dot{V}O_2$ ,  $\dot{V}CO_2$ , and  $\dot{V}E$ . However, pregnancy does not affect  $\dot{V}O_{2\text{peak}}$  in cycling or swimming.

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